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COMPARISON OF SIMULATOR SICKNESS SYMPTOMATOLOGY IN TWO FIXED-WING AND TWO ROTARY-WING SIMULATORS. Michael G. Lilienthal, Ph.D.,* Naval Air Systems Command; Robert S. Kennedy, Ph.D.*, Essex Corporation; Sherrie A. Jones, M.S., Naval Training Systems Center.

INTRODUCTION. Studies have found that moving-base simulators of rotary-wing aircraft with CRT displays produced the highest incidence of simulator sickness, as measured by self-report, postural, and visual tests. A standardized scoring technique was developed which facilitates comparison between simulators and a factor analysis revealed three distinct factor clusters corresponding to oculomotor, visual-vestibular, and neurovegetative systems. METHOD. Four simulators were examined in the present experiment. Two "sister" moving-base simulators (2F121) for the H53E helicopter and two fixed-wing simulators (2F114 and 2F143) for the A6E and EA6B aircraft. The helicopter simulator employ CRT infinity optics and the other two were dome projection systems. The 2F114 was a fixed base. Approximately 100 aircrew were observed in each simulator. RESULTS. Simulator sickness was found in all simulators when total scores were taken into account, with the highest incidence in the helicopter simulators. When the symptomatology was scored according to the three factor clusters, it was found that the CRT-based helicopter simulators had the highest reports of eyestrain and the fixed-base simulator had the highest reports of disorientation. Nausea was reported about equally in all three of the motion-base simulators. CONCLUSION. Different symptom clusters which occur in specific simulators with sufficient regularity suggest using this method of analysis in an attempt to identify specfic equipment features that relate to simulator sickness.

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NUTRITION AND ACCELERATION TOLERANCE: CURRENT UNDERSTANDING. G. H. Evans and L. P. Krock.* Valparaiso University, Valparaiso, IN 46383 and Armstrong Laboratories, Brooks AFB, TX 78235-5000.

INTRODUCTION: Nutritional status and the influence of diet on individual ability to perform in the increased acceleration environment is an important aeromedical concern. Although relatively more information has been generated regarding the nutritional needs of the infantry soldier, little data is available for the special case of the high performance pilot (HPP). METHODS: Approximately 5 decades of nutrition research and current sources of nutrition information for HPP under operational conditions were reviewed. Interviews, computer data base searches, and manual searches of earlier aeromedical literature provided sources for this review. RESULTS: Limited data are available from intervention studies addressing the effect of pre-flight meals and long-term nutritional status on acceleration and the nutritional requirements of HPP. Data showed an increased G-duration tolerance in the fed vs. fasted and induced hyper- vs. hypoglycemic states. Combined sodium and fluid restrictions are known to decrease G tolerance. No recent studies evaluate the energy cost of the high G environment. Although limited to one study, dietary recall data indicate nutrient intake was primarily similar to U.S. military standards. However, carbohydrate quantities consumed in two studies did not meet recommendations to HPP pilots, and types of carbohydrate were not differentiated. Surveys indicate pilots frequently miss meals, but the pre-flight food habits of U.S. pilots are unknown. CONCLUSIONS: More research is needed to determine optimum composition, size and timing of pre-flight meals, suitable composition of meal substitutes during operational conditions when time is short, and the effect of longer-term dietary intake on acceleration tolerance.

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THE INCIDENCE OF ACUTE ADVERSE HEALTH EFFECTS IN PILOTS USING A POSITIVE-PRESSURE BREATHING ANTI-G SYSTEM (PBG).
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INTRODUCTION. Modern fighter aircraft subject pilots to acceleration forces that can cause G-induced loss of consciousness (GLOC). Over 300 such cases have been documented since 1982; 15 have resulted in fatalities, all of these in fighters. The Air Force has thus sought to improve acceleration protection under a program called COMBAT EDGE. This system retains the conventional G-suit and valve, but additionally provides positive-pressure breathing during G (PBG) assisted by a counter-pressure vest. Pressure begins at +4 Gz, increasing 12 mmHg per G to a maximum of 60 mmHg at +9 Gz. PBG has been shown to more than double G-time tolerance in centrifuge tests. It has recently undergone operational test and evaluation (OT&E) in the F-15 and F-16, and is scheduled to be widely fielded in the near future. This study was undertaken to initially assess potential aeromedical issues. METHODS. All F-15 and F-16 pilots exposed to PBG during the test were anonymously surveyed at intervals over the course of the OT&E. As controls, non-PBG exposed F-15 and F-16 pilots were also surveyed during the same period. RESULTS. Dependent variables sought included neck pain, back pain, arm pain, gray-out, black-out, G-LOC, dyspnea, and cough during high-G flight. Early analysis reveals no significant increase in any of these acute adverse health events in pilots flying with PBG. CONCLUSIONS. Thus far, PBG appears to be safe with regard to the dependent variables tested. Long-term surveillance of pilots using PBG technology will continue.

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ACCELERATION PROTECTION AFFORDED BY POSITIVE PRESSURE BREATHING: THE INFLUENCE OF F-15 AND F-16 SEAT-BACK ANGLES. T. R. Morgan*, C. L. Brown*, J. W. Burns* and J. B. Bomar*. Human Systems Program Office, Brooks AFB TX 78235-5000.

INTRODUCTION. COMBAT EDGE (CE) is a new anti-G system permitting the optional selection of positive pressure breathing for G (PBG). Initially developed for use in F-16 aircraft, it was later selected for retrofit to the F-15 fleet. Evaluation of the prototype system thus included assessment of its effectiveness at the different seat-back angles used in each aircraft. METHOD. Conditions were structured to permit the comparative evaluation of traditional gear, CE without PBG, and CE with PBG, each at seat-back angles of 17 and 34 degrees, as in the F-15 and F-16 respectively. Each was scored on the endurance attained by experienced subjects riding a standardized centrifuge test profile to exhaustion. RESULTS. In comparisons with traditional gear the combined influences of introducing CE and PBG increased the endurances attainable from both seats (ANOVA $p<.05$ for F-15, $<.001$ for F-16). Incremental increases in endurance appeared to accompany the introduction of CE and PBG respectively, but were much larger, and statistically significant (paired-t test), in the F-16 case only. CONCLUSION. The endurance advantage conferred by PBG is thus demonstrable in both F-15 and F-16 seat configurations, but is more marked, and displays statistically definable increments, only in the F-16 case. How slight postural differences between the seats may cause this is unclear. Whether or not it will influence aircrew acceptance in either aircraft should emerge from ongoing operational tests.

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AEROBIC AND STRENGTH TRAINING EFFECTS DURING HINDLIMB SUSPENSION. JJ Hartley, MJ Plyley, NH McKee, RD Forsyth and W Rhodes. Departments of Physiology and Surgery, School of Physical and Health Education, University of Toronto, Toronto, Ontario, Canada, M5S 1A8.

INTRODUCTION. The hindlimb suspension model has been used to study the response of skeletal muscle to a simulated "microgravity" environment. The purpose of this study was to determine the influence of strength training (electrical stimulation) and aerobic exercise (treadmill running) on the response of the slow twitch soleus and the fast twitch plantaris skeletal muscles to six weeks of hindlimb suspension. METHODS. Female Wistar rats (275g) were randomly assigned to suspended (S, n=30) and non-suspended (NS, n=30) groups. Both groups were subdivided into sedentary, aerobic and strength-trained groups. Trained rats were removed from a harness during the training sessions (3 days/week). Muscle contractile function and morphometry were assessed at the end of six weeks. RESULTS. In S rats, soleus peak twitch tension (Pt, N/g), tetanic tension (Po, N/g) and mean cross-sectional areas (CSA, um2) of typesI and IIa fibers were reduced, respectively to 82, 78, 47 and 68% of NS values ($p<.05$). In group S, plantaris fiber CSA was reduced to 82 (typeI) and 81% (typeIIb) of NS values ($p<.01$). Within S and NS groups respectively, sedentary values (mean$\pm$sd) for soleus Pt (2.4$\pm$0.79, 2.8$\pm$0.82 N/g), Po (10.8$\pm$3.90, 13.8$\pm$4.08 N/g), typeI CSA (1696$\pm$240, 3552$\pm$457 um2) and typeIIa CSA (1715$\pm$256, 2234$\pm$841 um2) were not significantly changed by either strength or aerobic training.Compared to sedentary activity, strength training increased plantaris Pt by 23% in S and 29% in NS groups($p<.05$). CONCLUSION Intermittent aerobic or strength training intervention during prolonged hindlimb suspension may be ineffective in reducing the amount of muscle wasting due to simulated "microgravity" exposure.

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SKELETAL MUSCLE RESPONSES TO UNLOADING IN HUMANS. G Dudley, P Tesch, B Hather, G Adams & P Buchanan*. NASA & Bionetics Corp, Kennedy Space Center, FL 32899; Karolinska Institute, S10401, Stockholm, Sweden.

**INTRODUCTION**. This study examined the effects of unloading on skeletal muscle structure. **METHODS**. Eight subjects walked on crutches for six weeks with a 10 cm elevated sole on the right shoe. This removed weight bearing by the left lower limb. Magnetic resonance imaging of both lower limbs and biopsies of the left m. vastus lateralis (VL) were used to study muscle structure. **RESULTS**. Unloading decreased ($P<0.05$) muscle cross-sectional area (CSA) of the knee extensors 16%. The knee flexors showed about 1/2 this response (-7%, $P<0.05$). The three vasti muscles each showed decreases ($P<0.05$) of ~ 15%. M. rectus femoris did not change. Mean fiber CSA in VL decreased ($P<0.05$) 14% with type II and type I fibers showing reductions of 15 and 11%, respectively. The ankle extensors showed a 20% decrease ($P<0.05$) in CSA. The reduction for the "fast" m. gastrocnemius was 27% compared to the 18% decrease for the "slow" m. soleus. **SUMMARY**. The results suggest that decreases in muscle CSA are determined by the relative change in impact loading history because atrophy was 1) greater in extensor than flexor muscles, 2) at least as great in fast as compared to slow muscles or fibers, and 3) not dependent on single or multi-joint function. They also suggest that the atrophic responses to unloading reported for lower mammals are quantitatively but not qualitatively similar to those of humans.

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